APPLICATION UNDER UNITED STATES PATENT LAWS

Invention: **DIFFERENTIAL GPS AND/OR GLONASS WITH WIRELESS COMMUNICATIONS CAPABILITY**

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This is a:

[ ] Provisional Application

[X] Regular Utility Application

[ ] Continuing Application

[ ] PCT National Phase Application

[ ] Design Application

[ ] Reissue Application

[ ] Plant Application

SPECIFICATION

DIFFERENTIAL GPS AND/OR GLONASS WITH WIRELESS COMMUNICATIONS CAPABILITY

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to wireless systems. More particularly, it relates to a wireless telephone system (e.g., a cellular telephone) which transmits location information to a called party.

2. Background of Related Art

Wireless telephone systems are becoming available everywhere, and are now in wide use by many people. A wireless telephone system such as a cellular telephone system allows users to make and receive telephone calls via a portable handset.

Many cellular telephone systems provide a public service by allowing a user to dial special telephone numbers to, e.g., report traffic accidents, call police, etc. Perhaps most importantly cellular telephone systems allow a user to dial an emergency telephone number such as '911'.

In a wireline system, a 911 telephone call includes call related information to the called party (e.g., a street address of the caller) allowing emergency personnel to rapidly arrive at the correct address. Address information is transmitted in a 911 capable system to the called emergency center regardless of the ability of the caller to speak, giving emergency personnel crucial identity and address information even in the most extreme emergency cases where the caller is unable to speak.

The functions of 911 systems have become well known in the wireline telephone system, but use of a 911 call using a wireless telephone such as a cellular telephone presents its own challenges. For instance, since cellular telephones are able to roam just about anywhere,

address information is not indicative of the location of the cellular telephone at any one time. Thus, at best, when a 911 call is placed in conventional cellular telephone systems the location of the fixed component of the cellular telephone system, i.e., the location of the base station servicing the cellular telephone at the time of the 911 telephone call, is all the location information that can be transmitted to the emergency personnel. However, since base stations usually service cellular telephones within a very large area (e.g., many square miles), a 911 system is rather impractical using conventional cellular telephones.

A conventional solution which provides more useful location information to a called party includes a global positioning satellite (GPS) within a cellular telephone handset. Fig. 3 shows such a conventional cellular telephone **300** including cellular telephone functionality **302** combined with a GPS system **304**. Using the GPS system in the cellular handset, location information can be determined using the GPS, then transmitted to a called party during a 911 telephone call.

A 911 system in a cellular telephone system carries great potential. For instance, a caller who is moving may stay on the line while emergency personnel are en route to reach them, and the cellular telephone may provide updated location information to the emergency personnel as the 911 caller moves.

Ordinarily, a GPS system is at best accurate to about 10-15 meters (e.g., 30 to 45 feet). Certain factors such as what is known as the ionosphere delay effect can affect the accuracy of the GPS system in any particular location at any particular time. In a wide-open area, a 10-15 meter accuracy is close enough for emergency personnel to locate the calling party. However, in many situations (e.g., in a crowded building, on a crowded street, etc.), a 15 meter may not direct emergency personnel

To make matters worse, a GPS system may be adjusted to have less accuracy, e.g., about 100 meters (e.g., 300 feet). For instance,

in the United States, the Department of Defense may adjust the GPS system using selective availability (SA) to have a less precise accuracy at any time (e.g., when the national interest outweighs commercial use of the GPS system).

Thus, the accuracy of the location of the user transmitted during a 911 call is limited to the accuracy of the GPS system at any one time. Moreover, as the accuracy of the GPS system is manipulated, so is the ability of emergency personnel to quickly locate persons making 911 telephone calls from GPS equipped cellular telephones. During such times, use of a GPS system to provide location information to emergency personnel during a 911 telephone call becomes somewhat impractical or useless.

There is a need for a wireless telephone system such as a cellular telephone system which is capable of transmitting more accurate location information to a called party or other emergency personnel not only when the GPS and/or Global Navigation Satellite System (GLONASS) systems are operating in a less accurate mode, but also when the GPS and/or GLONASS systems are operating in a typical accuracy mode (e.g., 10-15 meters).

SUMMARY OF THE INVENTION

In accordance with the principles of the present invention, in a wireless communications system, a base station location determining system comprises a satellite positioning system receiver, predetermined location coordinates of the satellite positioning system receiver, and a module which determines a difference between a location signal received by the satellite positioning system receiver and the predetermined location coordinates.

A method of improving an accuracy of a received navigational satellite signal in a cellular telephone handset in accordance

with another aspect of the present invention comprises receiving location information from a navigational satellite system. A differential GPS correction signal relating to an error in the received location information is received. The location information and the differential GPS correction signal are combined to generate highly accurate location information.

A navigational system in accordance with the principles of the present invention comprises a satellite positioning system receiver, a a wireless communications front end, and a module adapted to output a corrected location signal comprising a location signal received by the satellite positioning system receiver and a correction factor received by the wireless communications front end.

A method of increasing accuracy of a navigational satellite system in a wireless communications device in accordance with yet another aspect of the present invention comprises receiving using cellular telephone functionality of the wireless communications device a differential GPS correction signal containing a location correction factor. A location of the wireless communications device is determined using a navigational satellite system portion of the wireless communications device. The location correction factor is combined with the determined location of the wireless communications device.

BRIEF DESCRIPTION OF THE DRAWINGS

Features and advantages of the present invention will become apparent to those skilled in the art from the following description with reference to the drawings, in which:

Fig. 1 is a block diagram of the relevant portion of a wireless system base station showing the combination of predetermined location coordinates such as longitude, latitude, and/or altitude, with information received by a navigational satellite system receiver such as a GPS or GLONASS receiver, to formulate a differential GPS correction factor for

use by cellular telephones, in accordance with the principles of the present invention.

Fig. 2 is a block diagram of a wireless communications device such as a cellular telephone including a storage area for a differential GPS correction factor received using cellular telephone functionality, and the combination of the differential GPS correction factor with a location determined by a GPS system, in accordance with the principles of the present invention.

Fig. 3 shows a conventional cellular telephone including cellular telephone functionality combined with a GPS system.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

The present invention relates to the implementation of a differential GPS or GLONASS system (collectively referred to herein as a 'GPS system') for use by a base station of a wireless telephone system (e.g., by a cellular telephone base station). The differential GPS system may be implemented in a base station or other convenient location for use by the base station in servicing users in communication with the base station. Using the differential GPS system, a differential location 'correction' factor is determined based on a difference between a received GPS location signal and a known fixed location of a GPS system receiver for the base station. A differential GPS correction signal containing the correction factor is transmitted to any or all cellular telephone users of that base station to allow the cellular telephones to improve the accuracy of location information independently measured by GPS receivers located in each of the cellular telephones. The differential GPS correction signal may be transmitted using a voice channel or a control channel of a particular connection, or using a separate broadcast channel to all users.

In accordance with the principles of the present invention, the differential GPS correction signal containing the correction factor is

received by the cellular functionality of a cellular telephone, and combined with the location information determined by the GPS functionality of the cellular telephone, to provide highly accurate location information determined by the cellular telephone.

The differential GPS signal may be used to increase the accuracy of the GPS system, whatever the current accuracy of the GPS system, allowing practical implementation of an emergency telephone system such as a 911 system using a wireless system such as a cellular telephone system.

As integrated circuit (IC) technology becomes more advanced, it has become possible to combine the base-band functions (and maybe even the RF functions in the future) of both a cellular telephone and a GPS receiver into the same or a small number of ICs, which in turn are implemented into a cellular telephone/GPS handset. Such cellular telephone handsets include both cellular telephone functions and/or GPS system related services. For instance, the GPS portion of the cellular telephone/GPS handset may be used for providing conventionally accurate (e.g., 10-15 meters) location information for use in, e.g., hiking, bicycling, or other travels.

In accordance with the principles of the present invention, when using the cellular telephone/GPS handset as a cellular telephone, a base station (e.g., the base station in communication with the cellular telephone/GPS handset) transmits a differential GPS correction signal to the cellular telephone/GPS handset to 'correct' for inaccuracy in GPS signals which are independently received by the cellular telephone/GPS handset.

Furthermore, the invention relates to the implementation of a differential GPS device using a correction factor received over a wireless communications system (e.g., using a cellular telephone channel) to

improve the accuracy of the GPS system to, e.g., within a few meters or less.

Fig. 1 is a block diagram of the relevant portion of a wireless system base station showing the combination of predetermined location coordinates such as longitude, latitude, and/or altitude, with information received by a navigational satellite system receiver such as a GPS or GLONASS receiver, to formulate a differential GPS correction factor for use by cellular telephones, in accordance with the principles of the present invention.

In particular, in Fig. 1, a base station **102** of a wireless communications system (e.g., a cellular telephone system) includes a navigational satellite system receiver such as a GPS receiver **106**. The base station **102** also includes storage for predetermined location coordinates **104**. The predetermined location coordinates **104** are determined using conventional techniques, e.g., using surveying techniques. The predetermined location coordinates **104** may include longitude information, latitude information, and/or altitude information regarding the precise location of the antenna of the GPS receiver **106**.

The longitude information, latitude information, and/or altitude information stored as the predetermined location coordinates **104** are preferably of high accuracy, e.g., to within less than one (1) meter, although the particular accuracy of the predetermined location coordinates should be determined based on the particular application.

The GPS receiver **106** of the base station **102** is preferably fixed, i.e., not movable, such that the predetermined location coordinates **104** will not change.

A differential GPS correction factor **100** is determined by the base station **102** based on a difference between location information received by the fixed GPS receiver **106** at the base station **102** and the known, highly accurate location information stored in the predetermined

location coordinates **104** of the base station **102**. This differential GPS correction factor **100** is transmitted to any or all cellular telephone handsets including GPS positioning capability serviced by the base station.

Fig. 2 is a block diagram of a wireless communications device such as a cellular telephone **200** including a storage area for a differential GPS correction factor **220** received using cellular telephone functionality, and the combination of the differential GPS correction factor **220** with a location determined by a GPS system, in accordance with the principles of the present invention.

In particular, the differential GPS correction factor **100** transmitted by the base station **102** is received by cellular telephone functionality **202** in a cellular telephone **200** and stored in an appropriate location. The differential GPS correction factor **220** is combined with current location information determined by a GPS system **204** using an appropriate combiner **210** to provide highly accurate location information to the cellular telephone module **202**. The cellular telephone module **202** may use the highly accurate location information, e.g., to provide exact location information to emergency personnel using, e.g., a 911 emergency telephone call. The highly accurate location information may be transmitted to the emergency bureau either in using the voice channel and/or a control channel.

The differential GPS correction factor **100** may be transmitted by the base station **102** to all active cellular telephones **200**. Alternatively, the differential GPS correction factor **100** may be reserved for use by users of the wireless communications system only for particular needs, e.g., during 911 telephone calls.

Moreover, the differential GPS correction factor **100** may be transmitted any number of times to a particular user's cellular telephone **200**. For instance, the differential GPS correction factor **100** may be

transmitted to the cellular telephone/GPS receiver **200** once with respect to any particular telephone call. For instance, the differential GPS correction factor **100** may be transmitted to the cellular telephone **200** during call setup with the base station **102**, or at some other appropriate time during the telephone call. The differential GPS correction factor **100** determined by the base station **102** is stored in an appropriate location **220** in the cellular telephone **200**. A one-time transmission of the differential GPS correction factor **100** (with respect to a single telephone call) may be appropriate if the accuracy of the GPS system in general is not frequently changing. Alternatively, a broadcast channel can be used to periodically or otherwise transmit the differential GPS correction factor **100**.

If the accuracy of the GPS system is subject to frequent changes, it may be preferred that the differential GPS correction factor **100** be transmitted to active cellular telephone/GPS receivers **200** on a more frequent basis, e.g., periodically during any particular telephone call (e.g., during 911 telephone calls). For instance, the differential GPS correction factor **100** may be calculated by the base station **102** periodically (e.g., once every second, once every few seconds, etc.), and transmitted to any or all cellular telephones **200** active at that time. Thus, more frequent changes in the accuracy of the GPS system due, e.g., to selective availability, changes in the ionosphere delay effect, etc., can be accommodated in accordance with the principles of the present invention to provide a cellular telephone handset **200** with highly accurate location information for use by, e.g., emergency personnel in relation to a 911 telephone call.

Use of the present invention is not limited to transmission of location information for the purposes of an emergency telephone call or for the implementation of a differential GPS system. Indeed, the principles of the present invention can be utilized to provide improved

location information in a variety of applications, e.g., to transmit a location of a child using the telephone to a parent at the opposite end of a telephone call.

The disclosed embodiments were described with respect to a differential GPS correction factor **100** determined by a servicing base station **102** in a wireless communications system. However, the principles of the present invention relate equally to a differential GPS correction factor **100** determined by a device separate from the base station **102** and communicated to the base station **102** for relay to active cellular telephones **200**.

A database of geological corrections may also be made available to a servicing or other base station **102** in a wireless telephone system to enable an even more accurate differential GPS correction factor **100** to be transmitted for storage and/or use in correcting location information determined by a cellular telephone/GPS receiver **200**.

While the invention has been described with reference to the exemplary embodiments thereof, those skilled in the art will be able to make various modifications to the described embodiments of the invention without departing from the true spirit and scope of the invention.